Science Unit: ***Electricity with Applications***
Lesson 4: ***Electric Motors***

School Year:	2008/2009
Developed for:	General Gordon Elementary School, Vancouver School District
Developed by:	Scott Morgan (scientist), Bernard Wan and Nathalie Menard (teachers)
Grade level:	Presented to grade 6; appropriate for grades 5 - 7 with age appropriate modifications
Duration of lesson:	1 hour and 30 minutes (revise as needed)
Notes:	This unit assumes that the class has had a lesson on circuits. See the Scientist in Residence Program *Electricity with Applications* science unit, *Lesson 2, Series and Parallel Circuits*. http://scientistinresidence.ca/science-lesson-plans/

It is highly recommended that power adapters be used instead of batteries. Batteries are not recommended because they can explode when shorted, are expensive and have a short life. Power adapters, on the other hand, are safer, last for years, contain circuits that protect them when shorted and cost much less per year of use. The typical 6-V battery used in schools costs $10 and lasts 1-2 years. A power adapter costs $20 - $30 but lasts for many years.

Safety precaution: If using batteries, be careful not to short the terminals of the battery as it will damage the battery and there is a danger of explosion. In other words, do not connect the terminals of the battery directly with a low resistance element such as a wire or any piece of metal.

Vancouver Elementary School Teachers: Please contact info@scientistinresidence.ca if you would like to inquire about the availability of materials and supplies for this science lesson.

Objectives

1. To learn how electromagnets can be used to create a motor.
2. To learn what factors affect the speed of an electric motor.

Background Information

For many jobs in our society, we require things to rotate in order to do work for us. Examples are: in a washing machine, motors pump water by turning a pumping screw, and move the agitator by pushing a pulling a connecting rod. In this lab we use the force created by the electromagnets to cause a rotation. To create a rotation in a motor, two electric magnets are created that are misaligned. Magnetic forces will tend to align the electromagnets. This is what causes rotation in the motor. Once the electromagnets are aligned, however, they stop rotation. In order to have continuous rotation, the movement of the electromagnets causes a switch that once again misaligns the electromagnets.

Vocabulary

Current	The movement of electrical charge.
Insulation	A material that does not conduct electricity.
Electromagnet	A magnet that can be turned on and off by with electrical current.

Magnet wire	Wire that is coated with an insulating lamination. It is used so that adjacent wires can touch without shorting.
Force	Something that changes the movement or shape of an object.

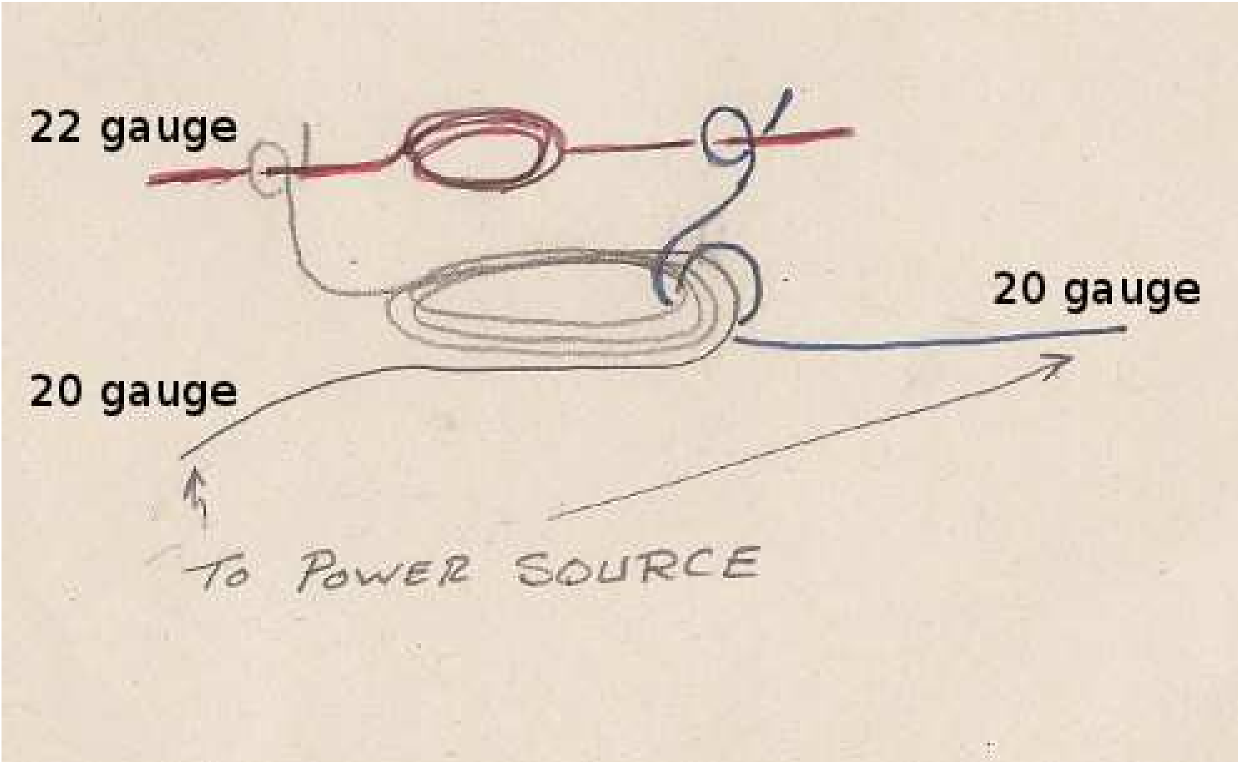
Materials (per student)

- Motor Kit made from 20- and 22-gauge magnet wire (see *Building the Kits* below)
- Xacto knife or razor to bare ends of wire (teachers only!)
- 2 small beads (optional)
- magnet
- power adapter 5-6 VDC, 2.5-3 Amp. (if power adapters are not available then batteries can be used – please see safety guidelines below)

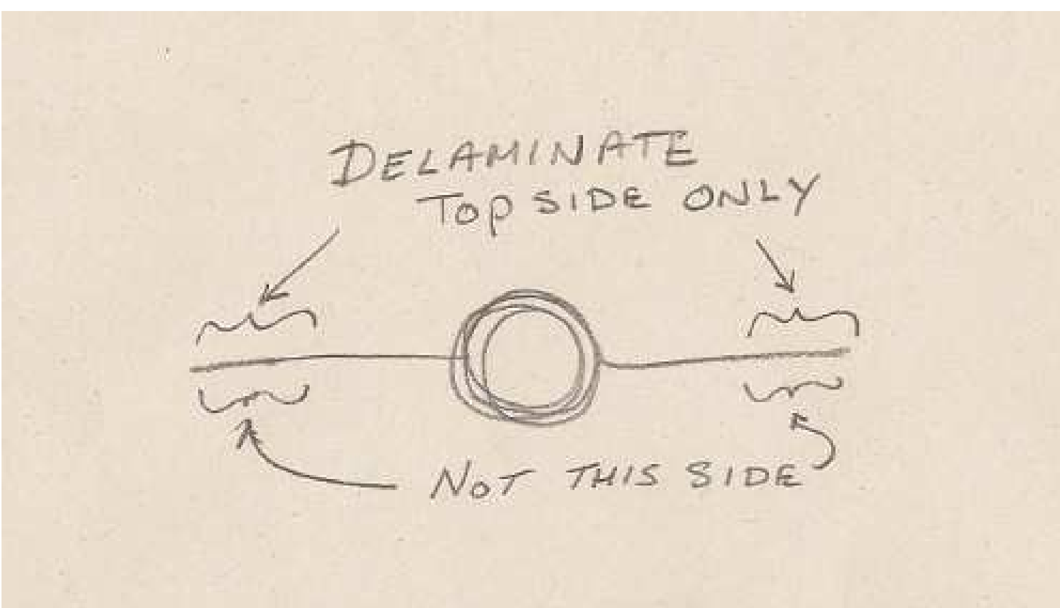
Building the Kits

The motor kit is shown in the figure below.

The following figure shows the arrangement of wires in the coils. The bottom coil is made by winding 50 turns of 20-gauge magnet wire around a C cell battery or something about that size, and the top coil is made by winding 70 turns of 22-gauge magnet wire around a AA cell, marker or something of a similar size. Cut another 20-cm piece of 20-gauge magnet wire. This will be used for the wire marked blue in the figure below. Use an Xacto knife to scrape 2.5 cm of lamination from both ends of both 20-gauge magnet wires.



Scrape 2.5 cm of lamination from only one side of both ends of the 22-gauge wire as in the following figure. Scraping just one side allows the end of the wires to act as switches, turning the motor on only when the de-laminated top coil wire makes contact with the de-laminated loops of the bottom coil. Test the motor by placing the top coil in the loops of the bottom coil as in the figure above, connect the leads to the power source using alligator clips and give it a spin to get the wires to make contact so that it can start spinning. If it does not spin reliably, you may have to straighten the leads of the top coil so that their axes go through the middle of the coil.



In the Classroom

Introductory Discussion

1. What is a motor? What is an electric motor? What to they do? Are there any in this classroom? Do you have any in your home? How many (take poll, show on chalk board). Could we live without motors? How different would our world be without them?

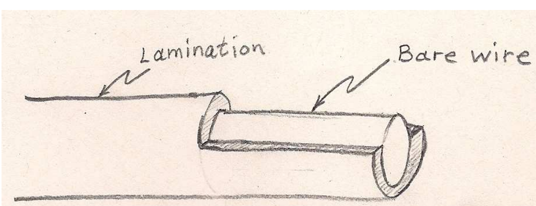
Science Activity/Experiment

Safety Guidelines
If using batteries: Be careful not to short the battery terminals as it will damage the battery and <u>there is a danger of explosion</u>. In other words, do not connect the terminals of the battery directly with a low resistance element such as a wire or any piece of metal.

1. Review that electric current creates magnetic forces. Magnets tend to align themselves.

2. Recall that a circuit is created when charge from an electric power source (*e.g.*, battery or generator) is allowed to flow through conducting elements (such a wire or metal) back to its source.

3. Students will create motors using two coils of magnet wire, and a power adapter. One coil will rest on the table and a second coil will be suspended above it (see the diagram below). Current will flow from the battery, through both coils and then back to the battery. The ends of the magnet wire making up the coils will be de-laminated to allow current to flow. The bottom coil will be fully de-laminated at both ends. Each end of the top coil will be de-laminated on only one side of the wire – this will allow for the magnetic field to switch off before the electromagnets align so that the top coil will continue to rotate.



4. What will happen when the circuit is closed (The top coil will spin. The top coil will rotate to align its magnetic field with that of the bottom coil. As the top coil aligns with the bottom coil, the lamination on one side of the top coil will break the circuit allowing the top coil to continue rotating. When it returns to its original position, the circuit will be closed again, causing the top coil to again re-align with the bottom coil. And so the cycle repeats, leading to a continuous rotation.)?

5. How might you make the motor turn in the opposite direction?

6. Predict what will happen when we place a magnet over the motor. What will happen if we orient the magnet in the opposite direction?

7. Students will observe that the top coil spins. They will see that they can make the top coil spin in the opposite direction by connecting the battery the opposite way. The will see that they can make the motor spin faster or slower by changing the orientation of a magnet held over the motor.

8. Students will sketch a diagram of the circuit showing clearly how current flows in the circuit.

9. Be careful not to short the terminals of the battery as it will damage the battery and there is a danger of explosion. In other words, do not connect the terminals of the battery directly with a low resistance element such as a wire or any piece of metal.

Closure Discussion

1. Did the circuit behave as you predicted?
2. Can you think of any more applications of electromagnets?

References

http://www.youtube.com/watch?v=QsnoVXXLhpw You Tube video: *Two Coil Motor* - shows this motor in action.

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